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Engineer Study Reports Pentagon Was Built Tough

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WASHINGTON, Jan. 23, 2003 -- The engineers who designed and built the Pentagon some 60 years ago would never have imagined that their concrete-and-steel facility, used by thousands of military and civilian personnel, could withstand the impact of a jumbo jet traveling hundreds of miles per hour. But it did.

Although the impact area where the jet hit the Pentagon was heavily damaged during the Sept. 11, 2001, terror attack, the building's structural systems limited much more serious damage, according to a report released today by the American Society of Civil Engineers. The report followed a seven-month-long examination and analysis of the Pentagon's performance during and immediately after the 9-11 terrorist attack.

Paul F. Mlakar, a technical director of the U.S. Army Engineer Research and Development Center in Vicksburg, Miss., met the press today in the same section where the plane hit. A team leader for the ASCE study group, he said, "The Pentagon survived this extraordinary event better than would be expected." The engineering society also studied damage to the Murrah Federal Office Building after the April 1995 Oklahoma City bombing.

"While this loss of life exceeded that of the Oklahoma City bombing, it is very remarkable that it was not worse," Mlakar said. "This can be attributed to certain features in the Pentagon's original design."

"The Pentagon Building Performance Study" found that the Pentagon's structural system at the point of impact redistributed the weight of the building among the columns left standing. This limited what engineers call the "progressive collapse" of the floors above. Progressive collapse is the failure of a structure in which relatively local damage to a structural element leads to a larger breakdown.

The Pentagon was built of cast-in-place reinforced concrete, and the floors consisted of a slab, beam and girder system supported on spiral-steel-reinforced columns. All of these may have prevented disastrous failure, Mlakar said.

Mlakar said the study revealed a terrorist-hijacked airliner, flying at near ground level, sliced through the Pentagon in a section that was being renovated. In less than a second, the fuselage penetrated 310 feet -- through the outer three rings -- and destroyed 50 massive columns on the first floor.

On impact, the aircraft fuel ignited the plane and exposed areas of the building's interior. Twenty minutes later, a small portion of the building collapsed from the weakening of structural supports by the fire.

The analyses also revealed that the plane's wing severed exterior columns but were not strong enough to cut through the second-floor slab.

Mlakar said the original structural design of the Pentagon allowed it to perform surprisingly well when subject to extreme forces. "An understanding of its specific features will be valuable to engineers who need to design structures to resist progressive collapse," he said.

The report also said recent Pentagon Renovation Program safety modifications, such as newly installed blast-resistant windows, also played a part in limiting casualties and saving lives.

Mike Sullivan, acting director of the Pentagon Renovation Program, said the construction and safety measures used at the Pentagon are significant to building professionals and the public.

"It explains what structural features and mechanisms contributed to the Pentagon's resiliency and how these features and mechanisms performed during the impact and ensuing fire," he said. "The report further underscores the usefulness and applicability of these systems in future building designs and other structures in which resistance to progressive collapse is critical."

http://www.defenselink.mil/news/Jan2003/n01232003_200301236.html